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ABSTRACT

This guide is intended to serve a two-fold purpose: (1) to familiarize the teacher with the jargon, issues, and concepts of energy problems, and (2) to assist the teacher in preparing a curriculum dealing with energy issues. The guide is divided into four chapters: (1) energy basics, (2) uses of energy, (3) conservation, and (4) future scenarios. Each section contains background information and activity descriptions. Each chapter is prefaced with a specification of objectives and a glossary of terms. (RE)

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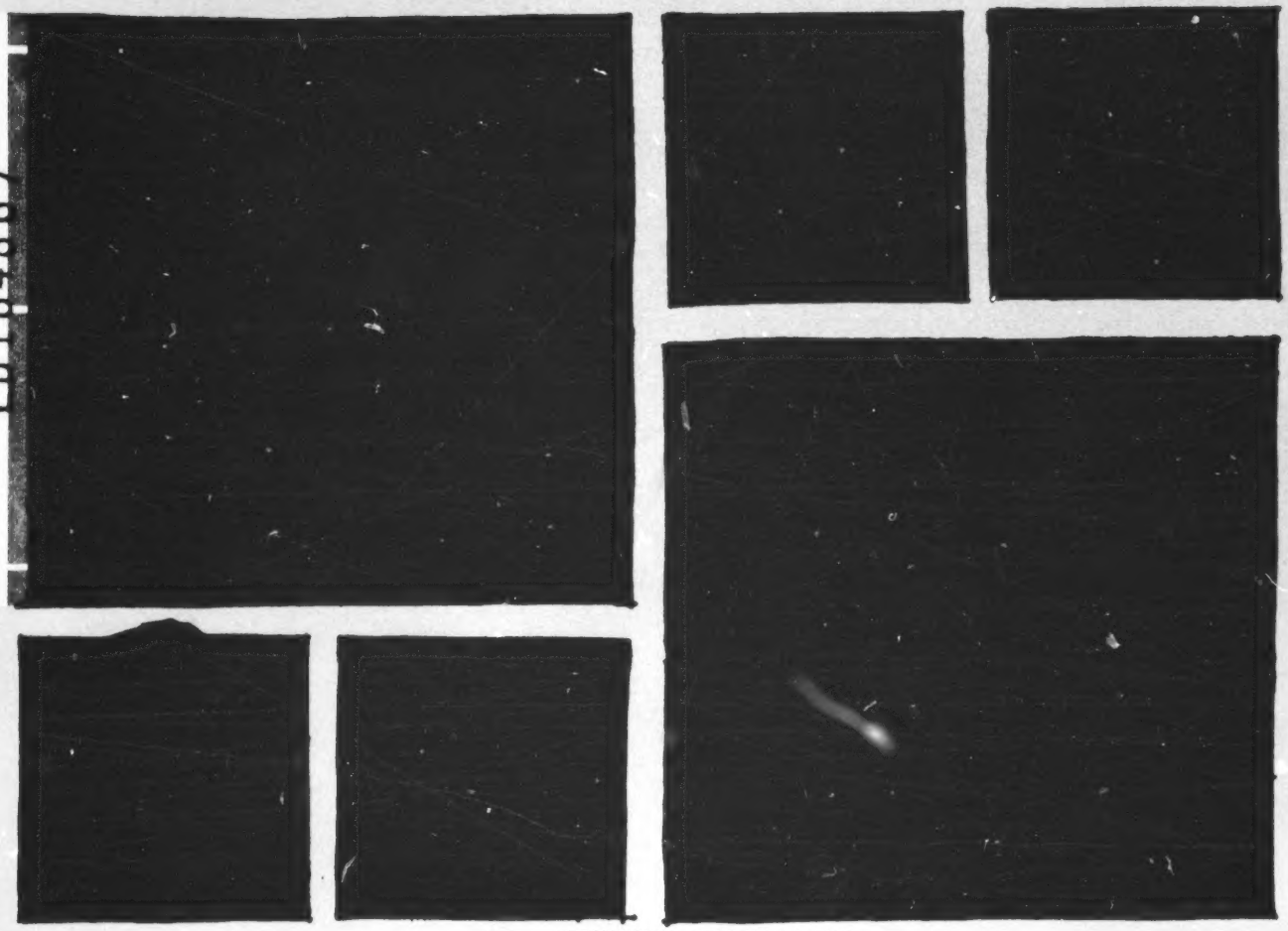
The Maine Teacher's energy primer



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the maine teacher's energy primer

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By TUX TURKEL

SUGGESTED FOR STUDENTS IN GRADES 5-7.

FOR THE ANSWERS THEY'LL WANT TO KNOW
TODAY, AND NEED TO KNOW TOMORROW...

ILLUSTRATIONS: MICHAEL LEWIS
DESIGN: SUZANNE BIRON & TUX TURKEL
LAYOUT & PRINTING: SUZANNE BIRON

SPECIAL THANKS TO SHARON LARANDO AND THE
SIXTH GRADERS AT SCARBOROUGH JUNIOR HIGH.

ALSO

GENE BERG, GEORGE SOULE SCHOOL, FREEPORT.
BILL GILLETTE, ZEPHYR WIND DYNAMO, BRUNSWICK.
JIM LIBBY, SCARBOROUGH JUNIOR HIGH, SCARBOROUGH.
CATHY MURRAY, OFFICE OF ENERGY RESOURCES, AUGUSTA.
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MAINE AUDUBON SOCIETY.

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a few words about energy education...

Having an awareness of energy and how it is used is a prerequisite for living in 1980's America. Actually, it was required reading during the 1960's and 1970's, although it never made the best seller list. Hence, the present state of affairs.

But there's no use crying over spilt oil. An entire generation of young Americans is out there, ready to inherit our energy legacy and set the matter straight. Some of them are probably in your classroom.

How can they get the full story on energy? It's not easy. For something so basic, energy is pretty complex. To add to the confusion, society has taken great liberties with the word. Our leaders tell us there is an "energy crisis." So we strive for "energy conservation" and "energy efficiency." Meanwhile, some people tell us the world is "running out of energy" and we've got to discover "new sources of energy." But somehow, that doesn't sit right with anyone who took physics in high school.

Confusion reigns. This curriculum is compiled with the belief that the student will have difficulty sifting through the jargon until the teacher feels comfortable with the material. The study of energy and how it is used in our world is complex. There's no getting around that fact. But there's no reason why developing a working overview can't be comfortable, for the teacher, and, for the student.

To make you, the teacher, more comfortable with this curriculum, a few words of clarification are in order. The text may seem different than those you've used in the past. The thrust is two-fold. THE MAINE TEACHER'S ENERGY PRIMER has been written in a conversational style which is designed to let you absorb the material in an enjoyable, step-by-step manner. Think of it as a bedside reader, if you'd like.

But it takes more than light reading to make a good course of study. There must be a way to convert thought into action. To make the transition, experiments, test questions and a host of discussion and participatory activities are suggested. It is hoped that this approach will provide you with the flexibility to turn the information into a full scale energy unit, integrate it with existing subjects, or anything inbetween.

chapter one: energy basics

OBJECTIVES

1. To provide a working definition of energy.
2. To identify the states and forms of energy.
3. To demonstrate energy conversions.
4. To define and demonstrate the First and Second Laws of Thermodynamics.
5. To emphasize the sun as the source of all energy.

GLOSSARY

1. ENERGY: the ability to do work or produce a change in temperature.
2. ENTROPY: the abstract phenomena that identifies the universal tendency of order to break down into disorder.
3. CONVERSION: in regard to energy, to change from one form or state to another.
4. FORMS: various situations in which energy can take place.
5. FUEL: a substance that contains a relatively high concentration of potential energy.
6. KINETIC: active, at work.
7. POTENTIAL: possible, stored.
8. POWER: energy use per unit of time; the rate of transfer of energy.
9. STATES: two conditions in which energy can exist.
10. THERMODYNAMICS: the study of heat flow.
11. WORK: the application of force through a distance.

Let's set the stage for energy study by first determining what it really is. People smarter than ourselves have determined that everything in the universe is either energy or matter. They also point out that these two entities can be changed or converted from one to the other. We're aware that energy from the sun is converted to matter when it makes a tree grow. Cut down the tree, burn it, and matter is converted to energy.

Matter really isn't that hard to understand. We can see it and touch it. But energy is quite a different sort of thing. It's really just an abstraction, a concept we've developed. Because it can't be seen or touched, the best way to understand what's important about energy is to pay attention to what it does, rather than what it is. We can define energy as the ability to do work or produce a change in temperature. To keep our definition of energy accurate, we should also clarify the meaning of work. Work is the application of a force through a distance, like a car moving down the highway. A student standing in the corner, holding a heavy book in outstretched arms, is not performing work.

The ability to do work or produce a change in temperature. That's energy. But if we can't see it or touch it, how can we keep tabs on what it's doing? Fortunately, energy exists in conditions that we can recognize. For the purpose of identification, we'll refer to these conditions as states. There are two states in which energy can exist. And, while energy can exist in two different states, it can be converted to several forms. States. Forms. Getting a bit confused? Let's clarify these terms with a little experiment.

EXPERIMENT: the old Energy Bag.

WHAT YOU'LL NEED: mousetrap, wooden kitchen matches, metal tray, raisins, flashlight, Energy Bag.

NOTE: the old Energy Bag is a standard concept that lends itself towards flexibility. Don't be shy about injecting a little creativity into the process. For example, a crumpled paper shopping sack will adequately serve as an Energy Bag. But at least one energy educator sports a brightly colored cloth container, complete with embroidered lightning bolt. The kids think it's pretty special.

Cram all the gear into the Energy Bag. Take care not to allow any young scholars to peer inside. Before proceeding any further, make sure everyone remembers the definition of energy. Now reach inside, fumbling, as if you're not really sure what's in the bag. Extract the mousetrap. Does the trap contain energy?

The class may be unsure. Carefully set the mousetrap and repeat the question. The fact is that now that the trap has been set it does contain energy. But is it satisfying our definition of energy? Is it performing work or producing a change in temperature? Not yet. But common sense dictates that we shouldn't place our fingers haphazardously on the trigger because experience tells us a sudden release of painful energy is possible. What this means is that possible energy is being stored in the mousetrap, at rest until it is called upon to perform work. This illustrates one of the states in which energy can occur, Potential Energy.

Now spring the trap. Use a pencil or ruler, please. Two things took place when the trap was released. Energy at rest, Potential Energy, was converted to active energy or energy at work. Energy in this state is called Kinetic Energy. (Students can remember this unfamiliar term by thinking of the state to our south, Connecticut.)

NOTE: A qualifier. Some physics professors might bristle at the idea of placing energy into the states of Potential and Kinetic. They might contend that, technically, all matter contains Kinetic energy on an atomic level. The moving molecules are always in a state of active energy. While technically accurate, most young students would probably not be comfortable with relating to energy on this level. Keeping energy within the

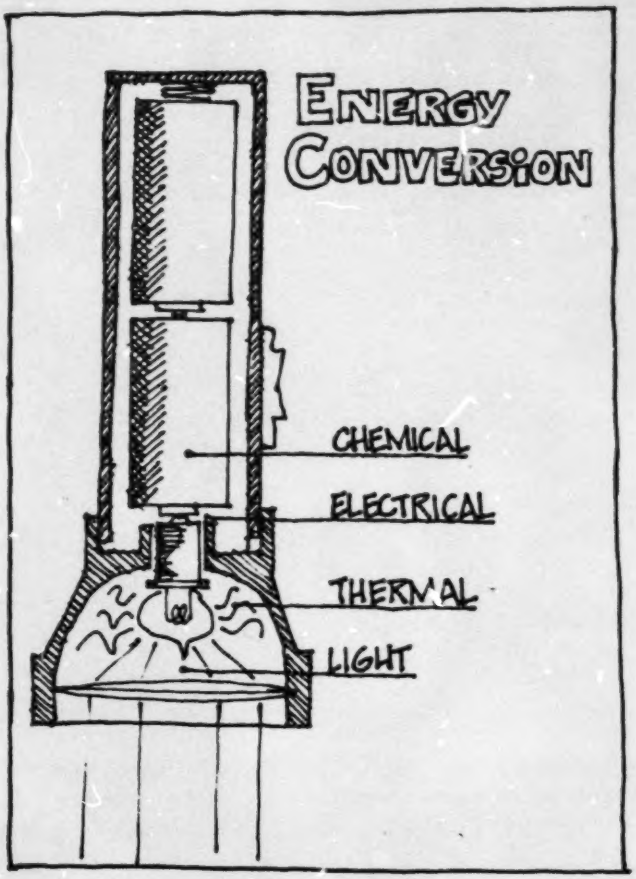
context of human experience is important for the purpose of this curriculum.

The mousetrap illustrated the two states in which energy can occur. It demonstrated how they could be converted from one to the other. The mousetrap also revealed to us a form in which energy can take place. That form is Mechanical Energy. What this really means is that Mechanical Energy was stored in the mousetrap in a state of Potential Energy. When the trap was sprung, Mechanical Energy moved to Kinetic Energy to perform work. After all, what is a mousetrap? It's just a small machine that can perform work.

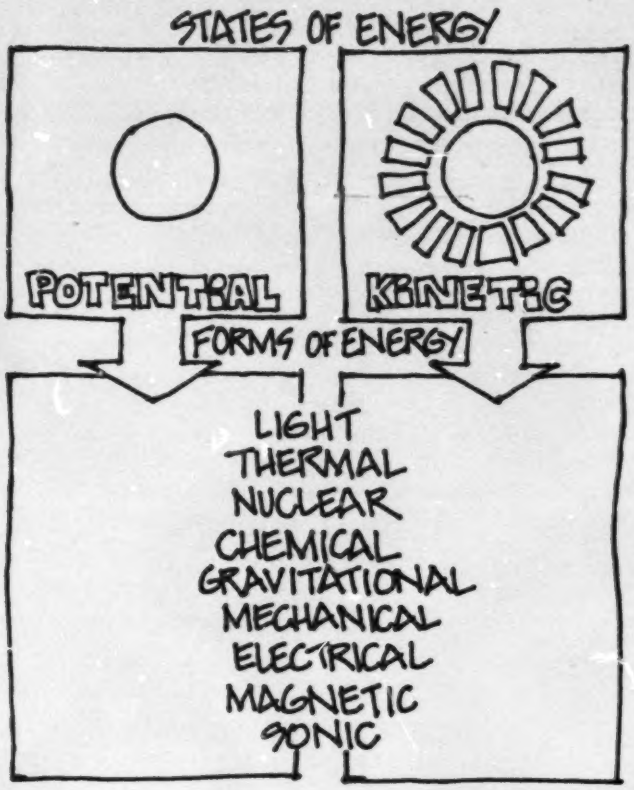
So much for the mousetrap. Put it aside and return to groping around inside the Energy Bag. Produce the flashlight. Ask the class again for our definition of energy. Does the flashlight contain any energy? Is it performing work or producing a change in temperature? By now, certain students will feel pretty sure there is energy stored inside the flashlight. That energy is stored in the batteries.

Now flip the switch. Instantly, a series of energy conversions have taken place. Let's trace the states and forms separately. Because the energy in the batteries was not performing any work or producing a change in temperature, we can assume it was in a state of Potential Energy. That possible energy was changed to active or Kinetic Energy when we completed the circuit. This change manifested itself in the following forms.

Chemical Energy, stored in the batteries, was converted to Electrical Energy. The Electrical Energy moved through the circuit and was converted to Light Energy at the lightbulb. But not all the Electrical Energy was converted to Light Energy. Some of it was converted to Thermal Energy, the small amount of heat given off by the bulb. Consider the conversions thusly:



Here's another way to think about the states and forms of energy.

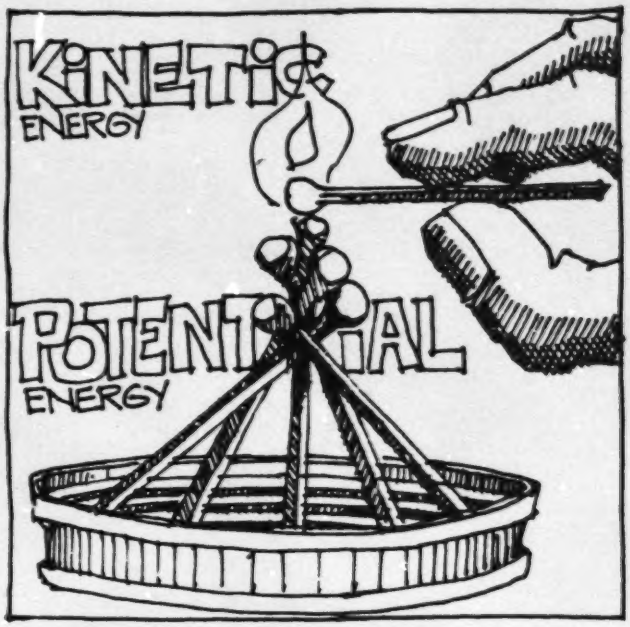


Take another grab into the Energy Bag. Out come the wooden matches. Once again, do the matches contain energy? By now, most everyone will agree that energy is being stored in the potential state. How can that energy be changed to active energy? Strike one match. Have the class note the two forms of energy that are being released, Thermal and Light.

Reach inside the Energy Bag and take out the metal tray. The tray actually serves no purpose in illustrating energy. In fact, it prevents a potentially excessive form of energy from being released. Burning down the school would be a graphic but unfortunate example of energy conversion.

Arrange several wooden matches on the metal tray. At this point, pause to reflect on what purpose the wood serves. We know from experience that after the head flares, the wood burns. When it stops burning the match "goes out." Speculation should lead to the conclusion that wood is acting as a Fuel. We can define Fuel as a substance that contains a relatively high concentration of energy. We can say that, when the match is ignited, Chemical Energy, stored in the wood, is converted to Thermal Energy and Light Energy.

Carefully light a match and ignite the little campfire. Ask the class whether they think there is an unlimited amount of energy stored in the wood. If that were the case, the fire would burn forever. We can feel the release of Thermal Energy as the fire burns. We can see the release of Light Energy. But there's more. We can also sense smoke being emitted. We should also be aware that gases, tars and resins are forming. Soon, the level of Thermal and Light Energy will decrease, bearing out our contention that there was a limited amount of energy stored in the wood. The fire has run out of fuel. All that remains is ashes. What actually happened to the energy that was stored in the wood?



The campfire was rather basic but it provided the perfect model for demonstrating what happens to all energy when it is used. In fact, the campfire illustrated the two most important rules or laws concerning energy. These laws can't be broken. They always happen the same way under the same conditions and are always obeyed in nature.

To those who took high school physics, the first law should be a flash from the foggy past. It states: Energy Cannot Be Created Or Destroyed.

But wait a minute. We live in a world where garbage is "thrown away." Waste is "flushed down the toilet." The earth is "running out of energy." The very idea that energy can't be originated or decimated is somewhat disturbing in our disposable society, especially when we're searching near and far for "new sources of energy." Let's see if we can put it all in perspective.

The idea that energy cannot be created or destroyed is commonly called the First Law of Thermodynamics. It's sometimes referred to as the Law of Conservation of Energy, but for the sake of simplicity we'll call it the former. Thermodynamics is the study of heat flow.

Putting the First Law into context with our little campfire, we can see that the energy stored in the wood was not really destroyed. It was converted to other forms. We know what the forms were. But another interesting thing is that the forms degraded to the point where they weren't good for much. They were no longer performing any work or producing a change in temperature. In the end, the energy was converted into forms that were unavailable for us to use.

The fact that when energy is converted, it degrades into forms that are more difficult to use to perform work or produce a change in temperature, underscores a second rule, a second law about energy. This is known as the Second Law of Thermodynamics. It states: All Energy Forms, In The End, Break Down To Less Usable Forms. Ultimately, there is a tendency for all forms to break down to Thermal Energy.

Why does this happen? The Second Law is enforced by a phenomena known as Entropy. We said energy is an abstract concept. Entropy is even more difficult to get a handle on. The Second Law underscores the universal tendency for order to break down into disorder. Entropy is the measurement of that disorder. It is sometimes thought of as the measurement of the unavailability of energy in a thermodynamic system. The important thing to remember is that all energy conversions ultimately degrade to less usable forms, notably Thermal Energy, making the universe a little more disordered.

This reality becomes apparent while scanning the ashes left in our metal pan. We know it's impossible to retrieve all the forms of energy (smoke, light and heat) and put them back into the matches. These forms of energy are truly lost to us forever. The campfire is a good example of this tendency towards disorder. It's easy to convert Chemical Energy to Thermal Energy, but quite another matter to achieve the reverse. There is no change in the total amount of energy available because, as the First Law tells us, energy cannot be created or destroyed. Total energy was conserved, hence the name Law of Conservation of Energy. But an irreversible process has taken place, a process making energy less useful and contributing to the disorder of the universe.

Back to the Energy Bag. Only one item remains in the bag, so rather than groping around, turn the sack topsy-turvy and spill out the contents---a box of raisins. Now comes the fun part. Energy education is hard work. Why not reward the class with raisins? Eating raisins in class (with permission) is almost as good as chewing gum.

So much for the fun part. Let's get back to work by tracing the energy conversions that just took place. Solicit a volunteer. The child who first raises his hand may serve as an example of energy conversions in the human body. Have the class follow along. When that student raised his hand, Potential Energy was converted to Kinetic Energy. Chemical Energy, stored in the form of food, was converted to Mechanical Energy. But children should be aware that their bodies are always in a state of Kinetic Energy. Even when sleeping, hearts are beating and lungs are exchanging air. At the same time, a certain amount of Potential Energy is held in reserve. This energy can be converted to perform certain levels of work. The relationship between food and the performance of work is well recognized. Manufacturers advertise "high energy" foods. We generally find it difficult to do heavy labor when hungry and have no doubt

heard people remark, "I just don't have any energy!"

Our bodies are constantly converting energy to different forms. We noted previously that Thermal Energy was an end result in all energy conversions and children should realize their bodies therefore maintain a temperature, 98.6 degrees F. To regulate this temperature, our bodies can perspire, accelerating the release of Thermal Energy. Performing greater levels of work generally speeds up the body's energy conversions, hence the acceleration of Thermal Energy. We can trace energy conversions and the First and Second Law of Thermodynamics through the body and its functions in a similar manner as the campfire. Our bodies take in energy as food, store some of it and convert some of it to active forms of energy to perform work and produce a change in temperature. Some of that energy is converted to less usable forms such as Thermal Energy (waste heat) and Chemical Energy (body wastes and exhalation).

We have addressed the big questions concerning energy basics, except one. Where does it come from? What is the source of all energy? The sun. The sun is the source of all our energy, and that fact is probably one of the most important concepts a child can learn. It is, therefore, the source of all life. The cosmic bottom line is that we just happen to be at the right place at the right time in our solar system.

The class should come to realize that the raisins are actually a form of solar energy. They are made from grapes which need sunlight to grow. All food is an example of indirect solar energy. Can you think of anything we eat that is not derived from the sun? Assist the class in tracing their favorite foods. What about the more subtle conversions, like hamburgers and candy?

chapter two: how we use energy

OBJECTIVES

1. To see how early man used energy.
2. To understand the difference between renewable and non-renewable resources.
3. To learn what these resources are and see how they are used.
4. To see how energy use effects our environment.
5. To trace mankind's use of energy and see how it is changing.
6. To relate environmental problems with contemporary energy sources.
7. To consider what our lives would be like without certain energy sources.

GLOSSARY

1. ACTIVE SOLAR: using solar energy in conjunction with other power sources and equipment, such as fans or pumps.
2. ELECTRICITY: an energy form existing as a current and identified as the directional movement of tiny, negatively-charged particles called electrons.
3. ENERGY DEMAND: the level of need we have for energy.
4. ENVIRONMENT: our surroundings; water, air and land.
5. FOSSIL FUELS: those fuels created millions of years ago through an organic fossilization process, namely oil, coal and natural gas.
6. FUEL SUPPLY: stock of materials used to produce usable energy.
7. HYDROELECTRICITY: electricity developed from water power.
8. NATURAL RESOURCES: substances found on the earth from which we extract energy in various forms.
9. NON-RENEWABLE RESOURCES: natural resources that are not able to be replaced.
10. NUCLEAR FISSION: the process of splitting atoms to produce heat.
11. PASSIVE SOLAR: the means of using solar energy without any additional power sources.
12. PEAT: an organic material formed by decaying or dead plants.
13. PHOTOSYNTHESIS: the process by which plants convert sunlight into stored chemical energy.
14. POLLUTION: the fouling or spoiling of our environment; any action that has a negative effect on the environment.
15. RADIOACTIVITY: harmful rays that are released during the atomic process.
16. REFINE: the distilling process by which the various fuel grades, such as gasoline and kerosene, are created from crude oil.
17. RENEWABLE RESOURCES: natural resources that can be replaced.
18. SOLAR COLLECTOR: equipment designed to gather sunlight and convert it to heat.
19. SOLAR ENERGY: energy from the sun.

We know energy is vital to all forms of life, hence our preoccupation with finding a steady supply of usable energy. We have a need for energy and that need is called Energy Demand. To meet this demand, we have historically enlisted a compatible Fuel Supply.

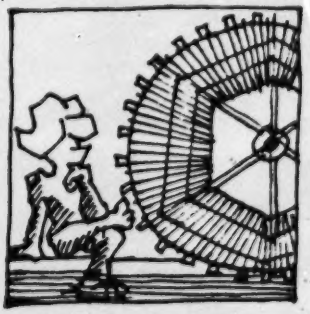
But supply and demand are constantly changing. The changing story of mankinds' demand for energy and search for usable supplies of fuel is directly linked to the changing levels of work he wanted to perform. We have said energy is the ability to perform work. To perform this work, new and increased supplies of fuel have historically been introduced.

ENERGY DEMAND AND NATURAL RESOURCES

Imagine what life was like in prehistoric times. What level of energy demand did our ancestors have? We can imagine that it was quite minimal. Primitive man was a scavenger, foraging for vegatation and small forms of wildlife. This method of using energy (food) assurred a low population level, keeping mankind in balance with his fuel supply.

As time went by man learned to hunt. He discovered how to construct weapons and the wheel. The secret of fire was revealed, and, just as important, the development of agriculture. These achievements had broad implications for our existence on earth. They gave the human race a fairly steady control over fuel supply (food) and permitted expansion to meet growing needs (demand). By combining hunting and agricultural skills, man was able to domesticate animals. Thus, he learned to harness the greater power of certain animals to perform greater levels of work. This standard of living may seem crude to some of us, but it should be emphasized to children that many regions of the earth remain at this level of energy demand today.

In other parts of the world, however, there was a desire to perform even greater levels of work. The creative intelligence of man was taxed to come up with ways to satisfy this desire. The challenge was met by taking advantage of more of the Natural Resources found on and in the earth. Wood was used to create fire and tools. Water power was employed to turn wheels that would perform work. Wind transported sailing ships to distant places. Wood, water and wind. These energy sources are not only natural resources, they are Renewable Resources as well. This means they can be replaced (renewed) in a relatively short amount of time.



If the world had continued along at this level of demand there would probably be no "energy crisis" today. But by the 14th century, some regions of the world had developed such a large appetite for energy that they could not be satisfied by renewable resources alone. People were using these renewable resources at such a rapid rate that, even though they could be replaced, they could not be renewed fast enough to keep pace with demand. To meet this new, increased level of demand, people began using resources that were not replacable. These irrepiacable sources of energy are called Non-renewable Resources.

The Non-renewable Resources that people began using are specifically known as Fossil Fuels. When we speak of Fossil Fuels we are referring to oil, coal and natural gas. These fuels were formed millions of years ago and are found inside the earth. Long before any humans lived on the planet, the earth was covered with dense swamps and forests. Tropical weather conditions prevailed, and, under these conditions, lush vegetation grew for millions of years. During several periods the oceans swept over the land, then receeded. This basic situation was repeated many times. Vegetation grew, died, decayed and was covered with water. The combination of water pressure, heat, bacteria from rotting organic matter and time created the fossil fuels we use so widely today.

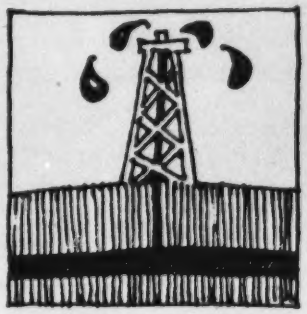
Wood is classified as a renewable resource because it can be replaced in a short period of time. A tree that is cut down can be replaced by another tree. Trees grow back. But fossil fuels are non-renewable resources because it would take millions of years under exacting conditions to create them again. When the present supply is depleted, it's obvious there will be no more for us to use.

The United States is presently more than 90 percent dependent on oil, coal and natural gas. That means that more than 90 percent of the energy we use daily comes from these fossil fuels. The state of Maine is also heavily dependent on fossil fuels. None of them are located within the state, however. They must be imported from other parts of the country and other parts of the world. Let's examine each one separately:

NON-RENEWABLE RESOURCES

OIL: Oil is often called Petroleum. This fuel source supplies around 60 percent of the energy we use in Maine. Deposits of oil are found trapped in rock beneath the earth. Deep holes must be drilled to release the oil. Small deposits are located in many places around the globe, but most of the oil currently used by the United States is found in Africa, the Middle East and North America.

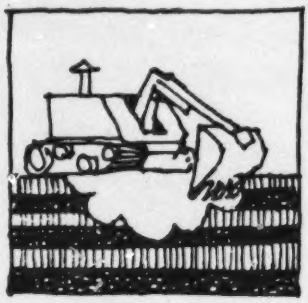
Oil is of little use to us in its raw form. We call it Crude Oil. Crude oil must be refined through a distillation process that extracts the various grades of fuel needed to run machinery and produce heat. These fuels include gasoline, kerosene and home heating oil. Petroleum is refined for hundreds of other uses, too. Lubricating oil is one of the more obvious byproducts, but petroleum is also used to make items ranging from medicine to plastic.



NATURAL GAS: Natural gas is often found in the vicinity of oil deposits. It is colorless and odorless. The smell associated with gas in injected by utilities as a safety measure. A highly refined fuel, natural gas is the end product of the geological process the created oil and coal. Natural gas is used in Maine for some heating and cooking applications, but it enjoys wider use in other parts of the country.

COAL: Coal is a solid, black organic material found inside the earth. Coal is mined either from the surface with giant shovels or via tunnels in the ground. Within the borders of the United States is more coal than in any other part of the world. The largest quanities are found in the Appalachian

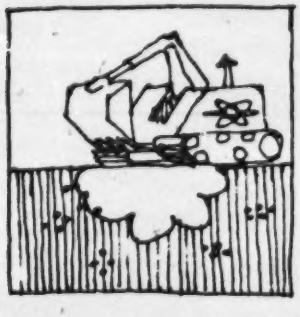
Mountains and in the western states. Coal is primarily used to generate electricity, although no Maine utilities currently burn coal.

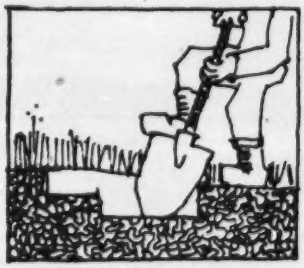


These fossil fuels satisfy the bulk of the nation's demand for energy, as we have said. But two additional non-renewable resources must be considered. While they are not associated with the geological process that results in fossilization, the time span required to replace them designates these fuels to the non-renewable category.

URANIUM: Scientists have discovered how to generate vast amounts of thermal energy by splitting atoms, the smallest part of matter that can retain its chemical composition. This process is called Nuclear Fission. Uranium, the most energy-intensive resource on earth, is used for this process. It is found in certain rock formations and extracted in much the same way as coal is surface mined. The heat given off by the atomic process is used to produce steam, which turns electricity-producing turbines.

PEAT: Peat is an organic material formed by decaying and dead vegetation submerged in water. It is found in bogs that take thousands of years to form. Peat has been burned as a source of fuel in some parts of the world for centuries and currently supplies nearly 30 percent of the energy needs in Ireland. Peat bogs do exist in Maine, although they are relatively small.





RENEWABLE RESOURCES

The remainder of the country's energy demand is satisfied by renewable resources. These include water power, (hydroelectricity) wood, wind and direct solar energy.

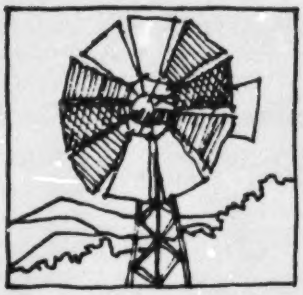
It is easy to see that renewable resources are directly dependent on the sun. But it is important to reemphasize to children that all non-renewable resources are products of indirect solar energy. The vegetation that grew and died for millions of years was dependent on that process called Photosynthesis. Solar energy was converted by plants and stored in the form of chemical energy. There are five major categories of renewable resources.

WOOD: We know wood as a renewable resource in the form of trees. In many parts of the world, however, wood plays an insignificant role as a fuel supply. But Maine is 90 percent forested and a 1978 study determined that almost half the homeowners in the state burn wood to some extent to keep warm in the winter.

HYDROELECTRICITY: Of all the renewable resources, water power supplies the greatest amount of energy on a nationwide scale. Water, held back by dams, is converted to mechanical energy when it falls to turn turbines and produce electricity. There are many hydroelectric generating stations on Maine rivers. More are being planned for the future.

NOTE: Hydroelectric dams provide a fine example of the principle of energy states discussed in Section A. Water behind the dam is considered to be in a state of potential energy. When it is released, when it falls thanks to gravitational energy, it is converted to kinetic energy.

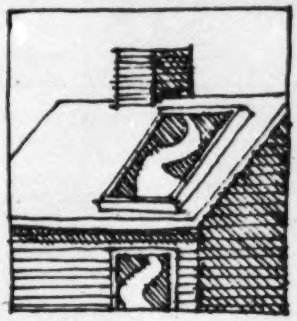
WIND: Uneven heating of the earth and water by the sun creates wind, moving air. We have all seen wind move a sailboat. But by constructing a windmill mechanical energy can be produced. That energy can turn a generator and produce electricity. Wind presently supplies little power in Maine. Most windmills are used to perform mechanical work, such as pumping water.

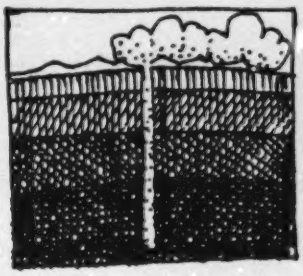


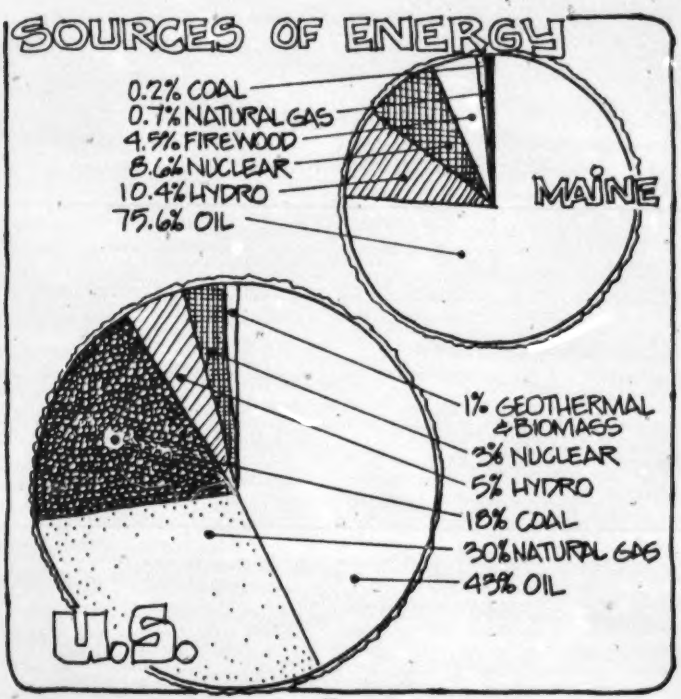
DIRECT SOLAR: We know the sun is the source of all life and therefore the source of all energy. We have seen many ways that solar energy can be stored and later used as chemical energy. But the sun can also be used directly for heat. This is called Direct Thermal Conversion. The sun can also be used to produce electricity, through a process called Photovoltaics.

When we stand by a sunny window we can feel warmth. It doesn't matter how cold the weather is outside. Methods are now being refined to use that heat and hold it for use when the sun is not shining. This direct energy from the sun, direct solar energy, is being used in various ways in Maine and around the country to heat water and warm living space.

GEOTHERMAL: There are several places on earth where the natural heat inside the earth combines with underground water to create steam. This steam is called geothermal energy. A geyser, such as Old Faithful at Yellowstone National Park, is an example of geothermal energy. By drilling holes by these underground heat sources, the hot water and steam can be extracted and used for heating and producing electricity. The only sources of geothermal energy in the United States are located in the west.







ENVIRONMENTAL CONSIDERATIONS

The word environment refers to our surroundings. In regard to the world we live in, we are speaking of the land, air and water. What does energy have to do with our environment? How are they related?

Consider the situation of primitive man. His energy demands were found to be rather simple, generally in the form of small animals and vegetation. There was little chance he would overwhelm his environment to satisfy his energy demand because the population was small. Vegetation that was eaten would grow back. Wildlife would reproduce.

But let's assume that one summer day, after man had discovered how to use fire, he was cooking his supper and the flames went out of control. Miles and miles of trees were burnt in the dry forest. Plant life was charred and local animals either died or fled the area. In this case, primitive man not only destroyed his energy supply (food), but ruined his environment as well.

This example underscores a third "rule" regarding the use of energy. There is no such thing as an "environmentally neutral" energy system. It's true that some forms of energy use result in a lesser impact on our land, water and air. But, all energy production has some effect on the environment.

The following take-home reading assignment further explains this reality by means of an historical outline of energy use in modern society. Included are a number of suggested questions about the reading.

TAKE-HOME READING ASSIGNMENT.

AN HISTORIC LOOK AT ENERGY USE AND THE ENVIRONMENT.

We have learned that the production of energy always has some effect on our surroundings, on our environment. We spoke about how primitive man destroyed his environment when his fire got out of control and burnt down the forest. Did burning the forest have a long-term effect on the environment? Probably it did not. That's because, even if primitive man destroyed a portion of the forest, he could move to another area and live there. The forest would grow again in a short time. Therefore, it would not take very long for nature to recover from the destruction.

But when man began the large scale use of fossil fuels to supply his energy he began having a greater effect on his environment. In some cases, man has done so much destruction to his environment that it may take many, many years to get back to normal. By looking back at history we can see how some of these events took place.

Wood was the choice fuel of western civilizations for many centuries. There was a lot of it around, it was easy to burn, and, as we have learned, it is renewable over a short period of time. But the population and demand for energy in some parts of the world grew so fast that trees were being chopped down at a faster rate than they could be replenished. Chopping down all the trees had two effects. It destroyed the environment (the forest) and it used up this source of energy.

As the wood began to run out, some parts of the world were forced to find another fuel source to meet their energy demand. To do this they started using coal. Coal had actually been discovered thousands of years ago, but it was not used very much until the year 1500. A good example of why coal became an important fuel can be seen by examining what the people in Great Britain were forced to do several centuries ago.

Great Britain is an island. It has historically been heavily populated. Because there were so many people living there, it did not take long for the demand for wood to overtake the supply. Wood had been in demand not only as an energy source, but for building as well. As a result, the British became the first nation in modern civilization to change their basic energy source from wood to coal. The reason was simple. They were running out of wood (it could not grow back fast enough) but there was a lot of coal underground. At the same time, other parts of Europe continued to burn wood

and did not switch to coal. The reason again was simple. They did not have as many people, they did not have as great a demand for energy, and there was still a lot of wood available.

What effect did this switch to coal have in Britain? Coal contains more heat energy than wood. As a result, the use of coal helped the British become an highly industrialized nation. In other words, they were able to use the greater energy in coal to perform greater levels of work. Coal was used to run steam engines and speed the development of a new form of transportation, the steam locomotive, the earliest railroad train.

The energy in coal brought about changes that made Great Britain a powerful nation. But coal use had its problems, too. Although coal contains a lot of energy, it is very dirty, hard to gather and difficult to move from one place to another. Mining coal is dangerous work and breathing the dust given off by coal is bad for human health.

Mining coal is not only dangerous, but it can have a negative effect on the land from which it is taken and the water that is found in the area. Burning coal also has its problems as it releases hazardous substances into the air. The effect of any substance or action that has a negative effect on the environment is called Pollution. For example, to pollute the water, to foul or contaminate it, is called water pollution.

Coal causes the biggest problems when it is burned, however. It causes a great deal of air pollution. The British knew this as they could see the black soot forming on their cities. The problem got so bad that in the 14th century, an English king issued a ban on coal burning in the capitol, London. To sum up, it is easy to see that while coal had some good effects (industrialization), it also had some bad effects (pollution). But Britain could not stop burning coal even if it chose to, because, as we have said, wood was becoming scarce and they had no other fuel available.

Things were a little different in the United States. We did not have such a large population and wood served as the main supply here until the Civil War.

Until that time our country had lots of wood in our great forests. But during the war the northeast became very industrialized and the factories and cities began using all the nearby wood. By the early part of this century the United States had switched from wood to coal to meet our higher energy demand.

Coal was used extensively in our country until around World War II. During this period we switched fuel sources again. This time we started using oil and natural gas. Why did we switch from coal to oil and natural gas when we still had plenty of coal left underground? You will recall the British switched fuels when they ran out of what they had been using. But we changed our primary fuel source for different reasons.

We changed from coal to oil and natural gas because these two fuels were easier to gather, easier to move from place to place, cleaner burning, and possessed a higher energy content in relation to their size. Coal, we remember, is dirty, hard to mine and causes a great deal of pollution.

We should realize that our country's decision to switch from coal to oil and natural gas was a very special decision. It was the first time in the history of the world that a civilization had made a major change in fuel sources merely because it was easier to use a new fuel source. Great Britain switched from wood to coal because they had to. We changed from coal to oil and natural gas because we wanted to.

This is not to say that oil and natural gas do not cause any pollution. They do. But they cause less pollution than coal and they are easier to use. That is why to this day around 75 percent of the nation's energy demand is met by these two fuels. Later, we will further discuss some of the environmental problems and supply problems with these two fossil fuels.

TEACHER NOTES

SUGGESTED QUESTIONS FOR READING ASSIGNMENT ON AN HISTORIC LOOK AT ENERGY USE AND THE ENVIRONMENT.

1. Can we produce energy without affecting the environment?

2. Did primitive man's burning of the forest have a long-term effect on the environment?

3. Why was wood the choice fuel of early man?

4. What happened to the wood supply in Great Britain? Why?

5. What two major effects did coal use have in Great Britain?

6. What is the definition of pollution?

7. What happened to the US fuel supply before and after the Civil War?

8. What fuel did the US switch to after coal? Why?

9. Why was the US switch from coal to oil and natural gas a special decision?

10. Do oil and natural gas cause any pollution?

ENVIRONMENTAL PROBLEMS WITH NON-RENEWABLE RESOURCES

Fossil fuels in the form of oil and natural gas are convenient to use. And oil and natural gas are relatively clean to use, much cleaner than coal. But through increased use we have discovered that they contribute to several serious environmental problems.

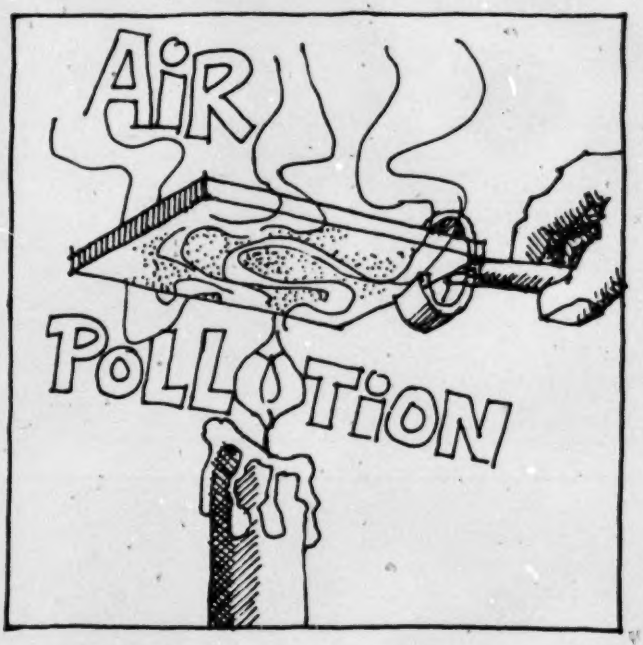
Gathering petroleum can have an adverse effect on land and water quality if oil is spilled at the drilling site. Such accidents can have an even greater impact at off-shore drilling stations. Great quantities of crude oil move around the world in large cargo ships. Shipping accidents can result in the release of this oil which can have a devastating effect on marine life, especially near the shoreline.

Crude oil is extensively refined into gasoline. Gasoline contributes to the largest form of air pollution in the United States, the automobile. The exhaust from motor vehicles (the result of incomplete combustion) contains such toxic substances as carbon monoxide and sulfur dioxide.

Natural gas must also be transported from the areas in which it is found to the places it is used. It is often moved via underground pipelines. Natural gas is also liquified by drastic cooling and moved in large pressurized ships. There is a danger that these ships, or the storage facilities they supply, could explode if accidently ignited.

EXPERIMENT: Illustrating air pollution.
WHAT YOU'LL NEED: Candle and glass.

When we see smoke being emitted from an automobile tailpipe, we are aware of air pollution. But some forms of air pollution, released whenever fuel is burned, are harder to identify. An easy way to show children how readily air pollution is released from ignited petroleum compounds is by using a candle and a small piece of glass, such as a microscope slide. The candle is made from paraffin, a petroleum byproduct. Ignite the candle and place the glass a few inches over it. A black powdery substance will form almost immediately on the glass. It can be smeared with a fingertip.



Another problem with oil and natural gas is that these fuels are becoming more difficult to find. Over the years we have located all the easy to discover deposits and must now look harder. Sometimes, in our haste to find new sources, we are careless with how we treat our environment.

Because we are running out of oil and natural gas in our country, a substantial amount of these fuels, especially oil, are being imported from other countries. This has happened in recent years because we began using more oil than we could discover and refine at home. Our leaders don't want the United States to buy so much energy from abroad. It costs our country a lot of money. To offset our dependence on imported petroleum, our leaders are encouraging us to use other fuel sources. One of these is coal. We mentioned earlier that the world's largest coal supplies are located underneath the United States. Therefore, an effort is underway to use more coal, especially to generate electricity. Does this sound like a good idea? What about the environmental problems associated with coal?

Another alternative to petroleum is nuclear power. Present atomic technology is limited to uranium, however, a non-renewable resource. In addition, only a small percentage of uranium is fissionable, that is, able to be split. Scientists are working on the development of a Breeder Reactor, a method for converting or "breeding" non-fissionable uranium into fissionable plutonium. Greater amounts of energy could then be extracted. Work is also underway to develop Fusion Reactors. Fusion is a means of colliding atoms together at high speeds under controlled circumstances. It is the same process by which the sun produces heat and is therefore thought of as our "ultimate energy source."

But nuclear power as it is used today has some special problems. The byproducts of nuclear fuel result in radioactive waste, a substance that emits poisonous rays. No permanent storage facility yet exists for these wastes, despite the fact they remain highly dangerous for thousands of years. In addition to these highly radioactive wastes, low levels of radiation can be given off from atomic power plants while they are in operation. The waste heat associated with these plants can also cause thermal pollution of the water and air.

ENVIRONMENTAL PROBLEMS WITH RENEWABLE RESOURCES

WOOD: Almost everybody in Maine knows someone who burns wood to warm their home in the winter. But widescale wood burning can result in environmental problems. Combustion releases smoke and gases, just as it did when we burned kitchen matches. This can cause air pollution when carried out on a large-scale basis or in congested areas. It is also important to manage our forests so that we don't burn wood faster than it can be replaced. Otherwise we could find ourselves in the same position as the early British.

WATER: Hydroelectric power is a very clean and efficient form of energy. But its potential is limited by the availability of flowing water. One solution is to impound large quanities of water for gradual release, although flooding vast areas and creating reservoirs can result in environmental damage.

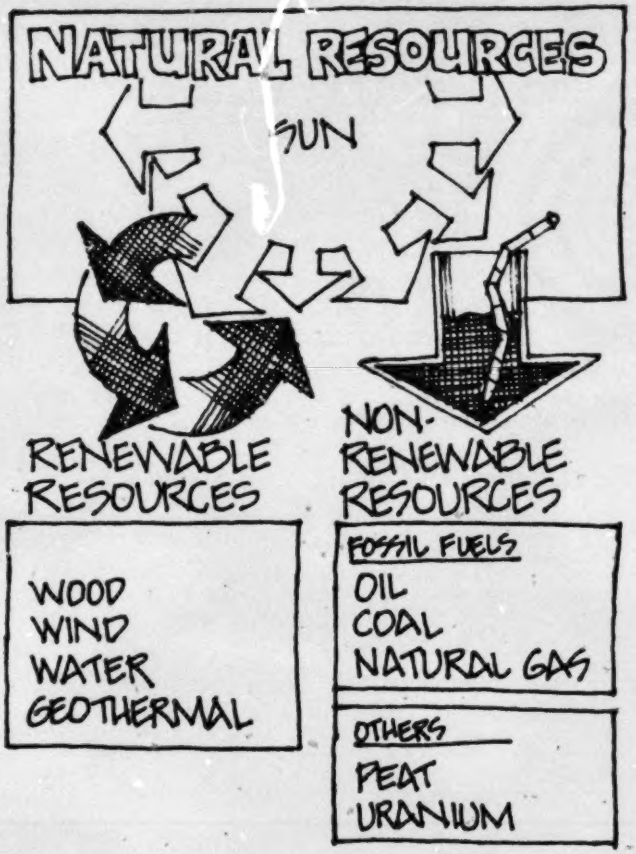
WIND: Wind power is a very clean form of energy, too. Windmills are used extensively for mechanical tasks such as pumping water, but are not very efficient for producing electricity. Because windmills only work when the wind is blowing, power must be either stored or used immediately upon production.

DIRECT SOLAR: Of all the renewable energy sources, direct use of the sun promises to be the most environmentally neutral energy source that can supply the greatest amount of power. Two distinct means of using the sun for space heating exist, Passive and Active.

Active solar heat relies on the use of Solar Collectors to capture the heat of the sun. Collectors work like a small greenhouse. They allow sunlight to enter but do not allow heat to readily escape. Their insides are a dark color to absorb heat better. The collected heat is moved with pumps or fans via water or air and stored for use when the sun is not shining.

Passive solar heat involves no pumps or fans. A good example of passive solar heat is what happens when you leave a car parked in the sun with the windows up. A passive solar house, for example, would take advantage of this principle by having most of its windows on the south side to receive as much sunlight as possible.

RESOURCE BLOCK CHART
This is a way to itemize the relationship between renewable and non-renewable resources.



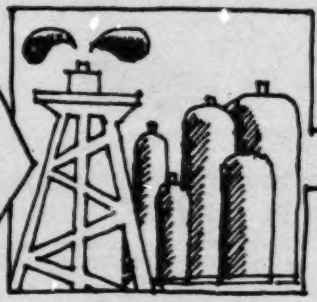
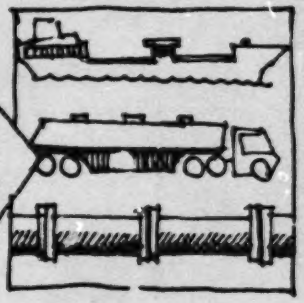
CRISIS SCENARIO
How do we use energy and how would our lives be without certain sources?

In reviewing various sources of energy and how they are used, we have been made aware that some are more useful than others. Some are more convenient than others as well. We have generally come to depend on those sources that are both useful and convenient. But what would happen if an energy source we were dependent on suddenly was not available to us? Do class members recall any temporary disruptions in electrical service that curtailed power to their home or school? Can a family member explain the Middle East oil embargo of 1973? To extend these temporary situations, what would have happened to the early British if, after running out of wood, they were unable to find another fuel source? What would happen in the United States today if we could not find the fuel we want when we want it? What about the gas lines of 1979? How would it effect everyday life?

As a homework assignment, children should spend a 24-hour period documenting the things they use energy for. Upon awakening in the morning, what procedures are carried out? What sources of energy are used in each procedure? For example, a typical day might begin by turning on the bathroom light. Where does the electricity come from? What about breakfast cereal? The school bus?

Children may not be able to trace all the energy sources completely. Discussion in class the following day should help point out the more obvious energy conversions and speculation should address the subtle forms. This sample worksheet could accompany the child home.

worksheet on next page

What You're Doing	Energy Form	Where it comes from	How it gets there
			

chapter three: conservation

OBJECTIVES

1. To understand that it takes energy to make energy.
2. To examine the relationship between the food we eat and the energy it provides.
3. To acknowledge that it takes time to develop new energy sources.
4. To emphasize the need to conserve non-renewable resources.
5. To discuss the responsible use of energy.
6. To perform energy audits on familiar buildings and to understand energy use patterns.
7. To encourage the following of energy-related events in the media.

GLOSSARY

1. AIR INFILTRATION: the flow of air through small openings in a building.
2. BRITISH THERMAL UNIT (BTU): the unit for measuring the amount of heat in a physical environment.
3. CALORIE: the unit for measuring the value of food for producing heat and energy in the human body.
4. CONDUCTION: heat flow through a solid.
5. CONSERVATION: to save or preserve our energy resources.
6. ENERGY AUDIT: an inventory of the way energy is used.
7. INSULATION: a material that minimizes heat loss by retarding its flow by conduction.
8. LAG TIME: the period between the time an energy source is discovered and the time it is producing power. Sometimes called Lead Time.
9. NET ENERGY: the concept that it takes energy to make energy.
10. PAYBACK PERIOD: the period between the time money is invested in a conservation measure and the time that measure saves money equal to the initial investment.
11. RETROFIT: to upgrade the thermal performance standards of a building.
12. WATT: a unit of electrical power.

Conservation has become the great American buzzword at the turn of the decade. Everyone thinks it's a good thing; when was the last time you heard a politician come out against conservation? Somewhere along the line, however, the true meaning of conservation has been squashed by the bandwagon-turned-steamroller. Still, conservation remains an essential part of the plan to develop new sources of fuel. In fact, conservation itself can be considered one of our most important new energy sources. Let's see why.

CONSERVATION AND NET ENERGY

Conserving energy means saving our resources. Since all energy production has an effect on the environment, saving energy helps preserve our land, water and air quality. Conserving energy also means saving money. It generally costs money to extract and develop energy sources.

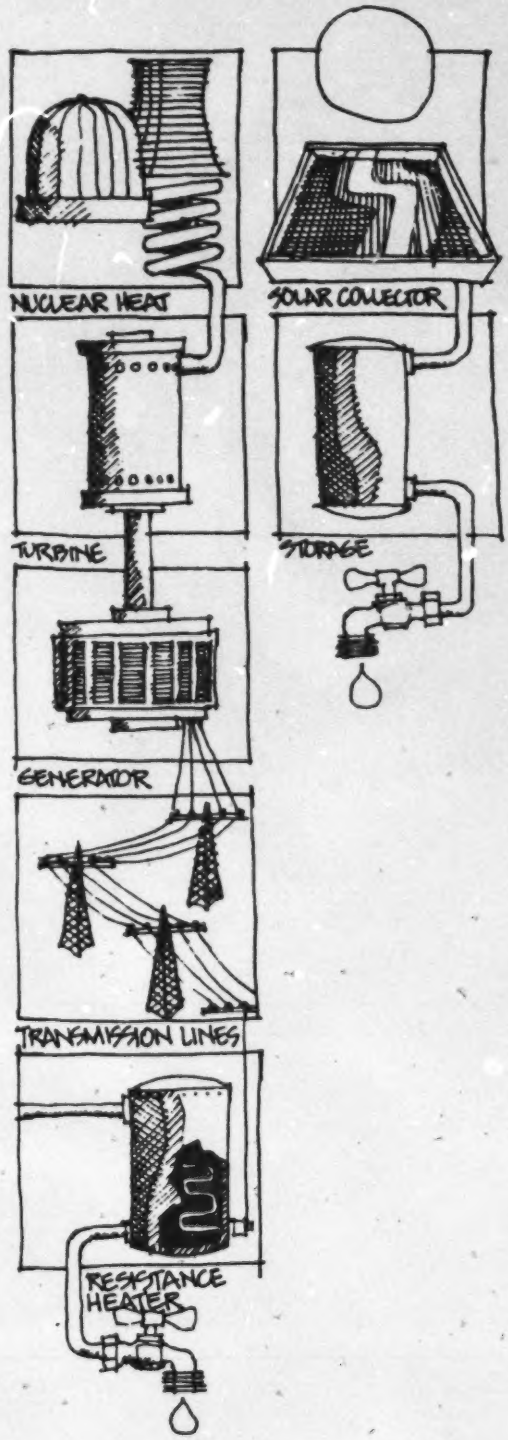
But these considerations are obvious. A fact that is often overlooked is that it requires varying degrees of energy to produce energy. Think back to the First Law of Thermodynamics. It states that energy cannot be created or destroyed. So to discover, develop and use new sources of energy, we must use existing forms of energy to perform the work involved in developing these new sources. Children should come to understand there is no free ride in this energy business. The concept is called Net Energy. We can remember it by this simple definition: It takes energy to make energy.

Getting a handle on net energy gives us an insight into the current state of energy affairs. People often remark that the sun's energy is free. But the equipment needed to harvest it takes energy (and money) to produce.

Consider the case for electric cars. This is a splendid example of net energy at play. Electric cars are often thought to be the answer to the "gasoline shortage." Some day, they may well be. But from where does the electricity come to operate these vehicles? If surplus power is available at a hydroelectric generating station, then conversion may prove economical. But what if the electricity is produced at an oil-fired station?

An easy way to determine whether more energy will be used than will be available in the end is with this equation:

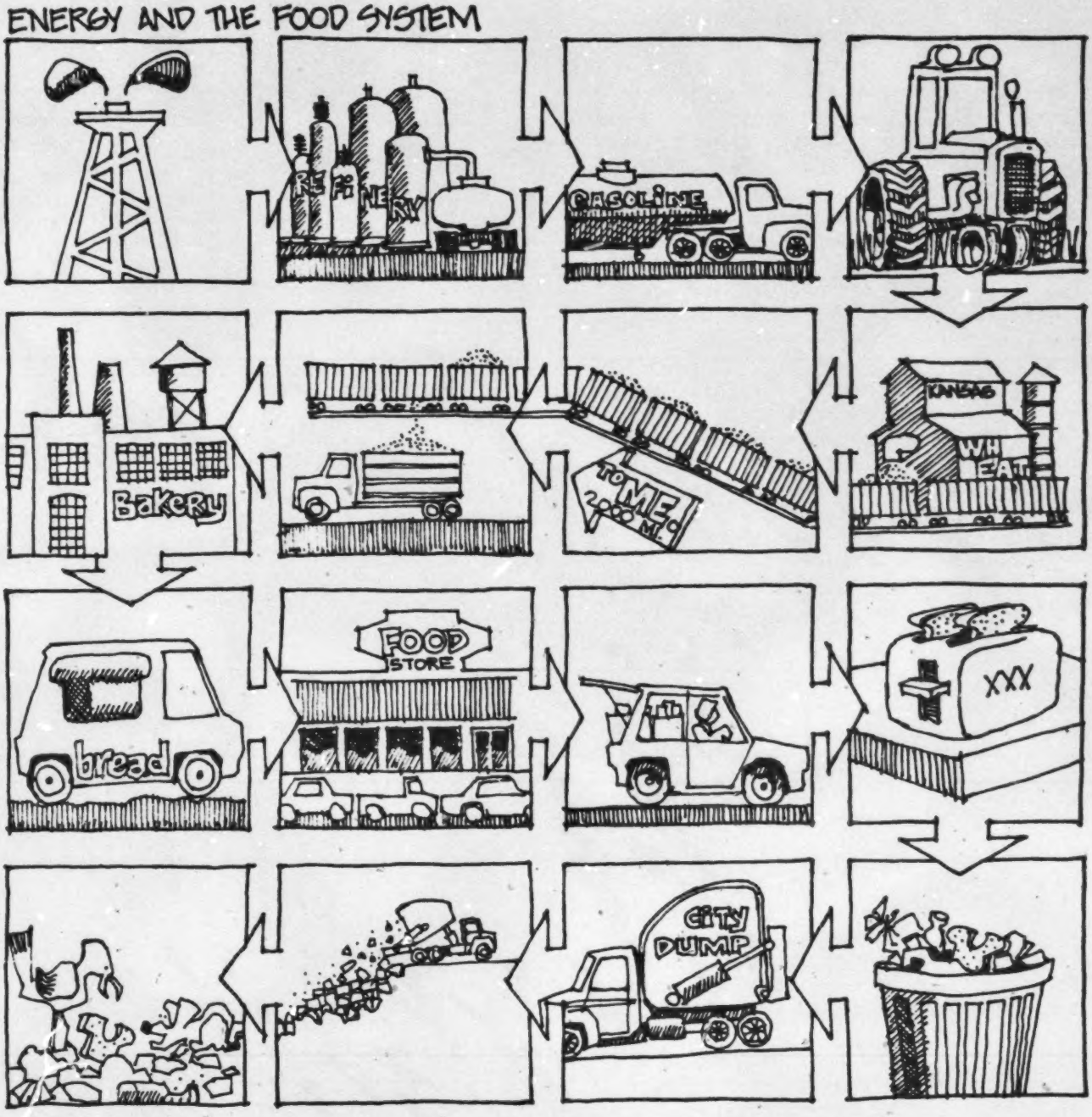
TOTAL ENERGY OUTPUT minus
TOTAL ENERGY INPUT equals
NET ENERGY



NET ENERGY AND THE AMERICAN FOOD SYSTEM

A final and compelling example of net energy is evident when examining the way in which our country's food distribution system operates. The drawing illustrates the route of an average loaf of bread.

To measure the value of food for producing heat and energy in the human body we use a unit called a Calorie. NOTE: the unit for measuring the amount of heat in a physical environment such as a building is the BTU or British Thermal Unit. To change BTU's to calories, divide by four.



Consider an ear of corn. Assume that fresh corn takes a total of 1,300 calories to produce. When eaten, it offers the body around 375 calories. Canned corn takes twice as many calories to produce, yet offers the body about the same as fresh corn. From a net energy standpoint, we don't make out too well when we eat corn. But it does taste good. And there are worse conversions.

A can of soda takes about 3,000 calories to produce yet the body only acquires 130 upon ingestion. Have students spend some time tracing the route of their favorite foods. They will not be able to come up with the caloric totals, but they will become aware of the energy intensive activities involved in the production of certain foods. The classic example is iceberg lettuce grown in California and trucked to Maine supper tables. What about Maine grown apples? Picked by you in season or found in the supermarket during the winter? What about fiddleheads in the spring? From an energy standpoint, should Maine try to grow more of its own food?

LAG TIME

Money, energy and the environment. They are all factors in the production of new fuel sources. But we've left out one important aspect. Time. Here's the kicker, the Catch-22 of energy production. It takes time to produce usable sources of energy, particularly the highly refined technologies that make our world tick.

Coal is a case in point. We know there's a lot of it under the United States. But it takes time to discover desirable mine sites. It take time to develop these sites and extract the coal. It takes time to move the coal to where it will be burned and it takes time to build the power plants that will burn it. When safety and environmental considerations are added to this schedule, we can see why it takes years from the time coal is found until the time it is producing power. There's a definite lag between the time we want power and the time we can start producing it. The period between the time a new source of energy is discovered and the time it takes before it begins producing power is called Lag Time.

Money, energy, the environment. And now, time. There are a number of obstacles in the way of developing new sources of energy. Since there are so many obstacles, it makes sense not to waste the sources of energy that are currently available. It makes sense to save what we have and make the most of it so we can "buy time" for developing the sources of energy we'll need in the future.

When we buy time, we also "buy" a cheaper source of energy---conservation. When we put insulation into our homes we cut down on the amount of energy we need to stay comfortable in cold weather. If all homes in Maine were heavily insulated, the state would have less of a demand for energy. There would be less need to build more power plants, a prime culprit in the rising cost of energy. Therefore, by not increasing our demand for energy, we not only save energy but save money as well. We can use that money for other things.

These are the reasons why conservation is important and why conservation makes social and economic sense. Money you don't spend is like money in the bank. It's money you can use when you need it. Energy is like that, too, at least usable energy. That's why conservation is often considered to be an important source of energy in itself.

RESPONSIBLE USE OF ENERGY

We now have a clear idea of the benefits of conserving energy. But certain functions of our society continue to be essential, or at least desirable. Certain levels of work remain to be performed. This poses a question. Is it possible to use less energy and perfrom the same amount of work?

Relatively, yes. The classic situation exists daily with the automobile. Two commuters live in the same area and must drive 30 miles to work in the same city. Commuter A, piloting his 1980 Guzzler Elite, can drive 15 miles on a gallon of gasoline. Commuter B, behind the wheel of a 1979 Frugal, manages 30 miles per gallon. Essentially, the same amount of work is being accomplished, and the class should be able to decide which vehicle is more efficient, and by

what margin. Someone might suggest that if these two commuters lived nearby and were on the same schedule, they might carpool. How many "people-miles-per-gallon" would they then achieve?

The automobile is only one example of how machinery can be designed to be energy efficient, that is, to waste as little energy as possible to accomplish the work at hand. How does the idea of energy efficiency relate to homes, school, and appliances?

ENERGY PHILOSOPHY

Elementary age children aren't generally exposed to philosophical discussions, especially in regard to how their everyday world got the way it is and how it might change in the future. A stimulating classroom discussion can result from the query, "what is a luxury, in terms of energy use?"

Is heating a luxury in Maine? How about air conditioning? Hair dryers? When we look at how energy is used, what is the difference between a luxury and a necessity? Is there a moderating point where certain items fall into neither category, or both? Should we use luxuries that require a large amount of energy? Who makes the decision, the government, ourselves? What is the effect if only one person decides to conserve energy? If many people join in? Does conserving energy have to be painful or inconvenient?

As an example, assume we can save the same amount of energy by either keeping our house at 50 degrees in winter, or insulating it and maintaining a temperature of 68 degrees. What would be the effect of keeping the temperature at 68 degrees without insulation?

CONSERVATION AND THE MEDIA

Social scientists are quick to point out the small percentage of the electorate that turns out to vote in any given election. They imply that the democratic process suffers from uninformed, apathetic citizens. Society's attempt to stay abreast of the changing world of energy has suffered from the same problems. To make matters worse, the lack of information is supplimented with a great deal of misinformation.

Energy dialogue is subject to numerous contradictions. The government blames the people and the people blame the government. Everybody blames the oil companies, and OPEC. Some people insist there's an energy crisis. Others say the crisis is fabricated. Everybody blames the oil companies, and OPEC. But a 1977 Gallup Poll revealed that half of all Americans didn't even realize the country imported oil from abroad.

The point of all this is that young people need to be better informed, in many cases, than their parents if they can ever hope to make intelligent decisions concerning energy use and the world they will inherit. The best way to learn how energy can be conserved and used wisely is to understand how it is presently being used and how it might be used in the future. The most comprehensive, long-term means of achieving this goal is through the media. It is difficult these days to open the daily newspaper without finding an energy related story. Ditto the six-o'clock news.

Most teachers encourage the study of current events. Current events and the study of energy go together like peas and the fourth of July. Students should be assigned the task of finding energy articles from local papers and magazines to bring in for class discussion. How do these stories relate to what they've learned about energy in general and their daily lives specifically? This would make a splendid weekly activity to carry over after the basic energy unit is completed. As a side benefit, they might even learn about other things while leafing through the newspaper.

Bangor Daily News May, 1979

Youths offer energy ideas

MACHIAS — Physics students at Machias Memorial High School, dissatisfied with what has not been done by politicians to control the growing problem of assured and available energy, are mailing their recommendations to leading politicians across the nation.

A letter sent to the president, the Maine congressional delegation, and energy officials contains the following recommendations:

—Develop a mandatory energy conservation education program for elementary school children.

—Convert all oil-burning electricity generating plants to coal.

—Demand the manufacture of cars with a minimum of 18-miles-a-gallon consumption.

—Build more dams and rebuild all current hydroelectric plants.

—Give tidal power more priority.

—Improve railroads.

—Allow insulation installment and other methods of energy conservation as tax credits.

—Advance technology in the areas of wind and solar energy.

STANDARD OF LIVING

Most Americans take certain things for granted that people in many parts of the world can only dream about. All our favorite toys, like cars and televisions, require energy. The United States has six percent of the world's population, yet we use one-third of the globe's available energy. Almost 40 percent of our country's total energy consumption is accounted for by personal use, things like heating, lighting, cooking and transportation. On a per capita basis (relative to population) Sweden uses half as much energy as we do, but maintains a comparable standard of living.

Children should consider the following questions. Does this situation seem fair? What about the nations that still use animals to supply many of their power requirements? Do we use energy for things we don't really need? Do we waste energy? Should anything be done about this situation, and why? How do you think other countries feel about the US? How do we view our foreign neighbors?

ENERGY AUDITS

Almost 20 percent of the total energy used in the United States is consumed in the residential sector. That doesn't represent the largest segment of energy use, industry does. But the residential sector is the area where students have the most experience. It is also the area where rising energy costs "hit home" for the average consumer.

When we think about it, we know enough now as a society to construct dwellings that would require very little non-renewable energy to sustain them. Our newfound knowledge would be fine if it wasn't for the millions of inadequately designed buildings already in existence. It would be one thing if entire cities were bulldozed and new, energy efficient structures erected. But that would not be practical or desirable, and besides, it would require a great deal of energy. The fact is that most of the buildings we'll be living with in the year 2000 are already standing. We've got to find more efficient ways to heat, light and cool these structures.

Before jumping in to the methods of how we might do this, have the class consider this theoretical situation:

Suppose you were sitting in your living room one winter day and somebody came along with a saw and cut a hole in your wall. The hole measured six inches long by five inches wide. Through the hole you could see outside. What effect do you think this hole would have on your heating system and your personal comfort in general?

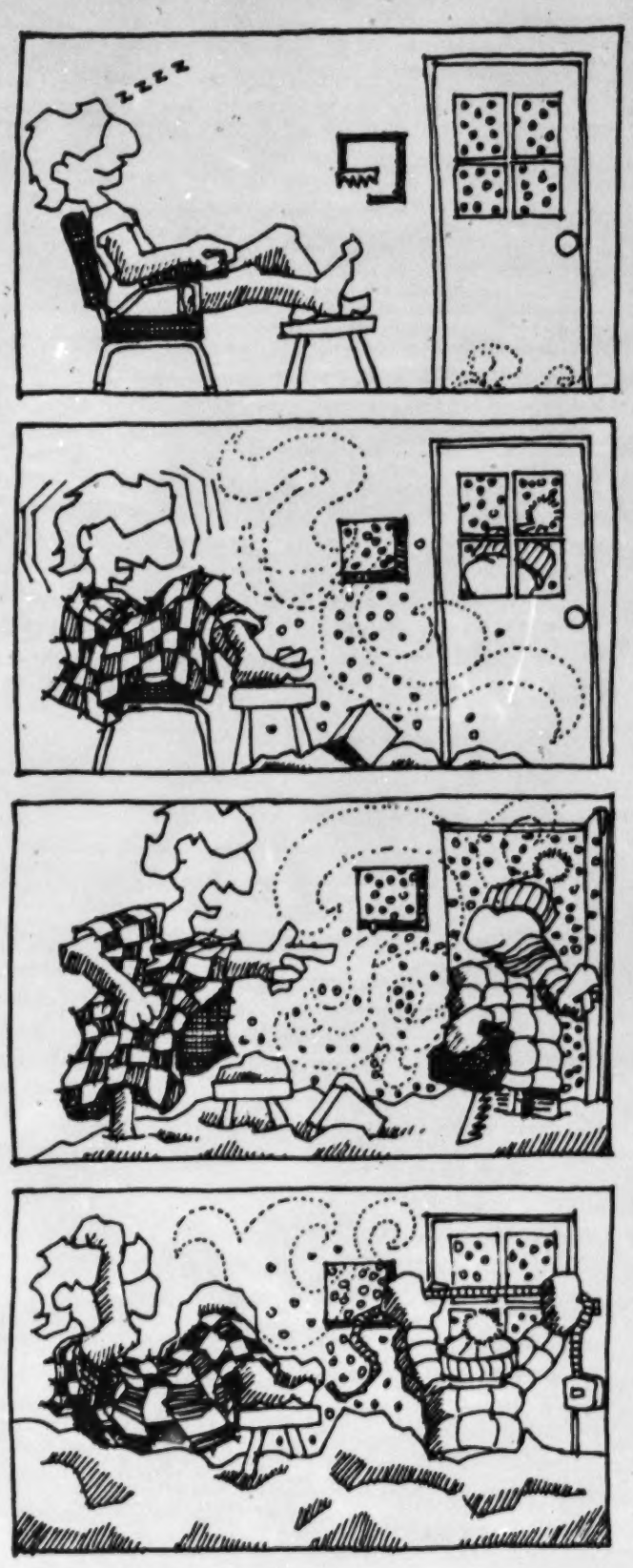
After discussing the obvious liabilities of having such a gap, explain that a 1/8 inch crack around the edge of an exterior door has a surface area of almost 30 inches. That's about the same area taken up by the hole in the wall!

It becomes apparent that small cracks add up and allow a great deal of cold air to enter a heated building. This is known as Air Infiltration. Can students think of any drafty doors in their homes? Any drafty windows? Could having a home with drafty doors be considered just as silly and wasteful as living in a house with a hole cut in the wall? How could this situation be rectified? Has anyone ever heard of weatherstripping?

THE IMPORTANCE OF ENERGY AUDITS

To seek out ways that energy is being wasted in a building is to conduct an Energy Audit. To raise the thermal performance standards of that building is known as Retrofitting. An energy audit should always be performed prior to retrofitting. Why? An energy audit helps us find where the biggest areas of waste are and identifies the ones that are the easiest to correct. It also helps us find the areas of waste that are the least expensive or most cost effective to correct. To sum up, an energy audit helps us find the best areas to retrofit. It is important that children realize that most people can't afford to save energy unless they can also save money. That's why energy conservation, in general, must make good economic sense.

One method of finding out how cost effective saving energy will be in any particular case is to compute the Payback Period. That's the period between the time



we invest our money in a conservation measure and the time that measure saves us money equal to our initial investment.

EXAMPLE: In calculating a real-life payback period, such factors as the rising cost of fuel and inflation would be taken into consideration. But young scholars should be able to figure out simplified versions. The concept of payback periods can be integrated into math studies.

Suppose that in 1978 we heated our house with oil for $500. In 1979 we bought a wood furnace and a large supply of wood for $2,000 to heat our house. If the price of oil did not rise (good luck) and our supply of wood lasted for several years, how long would our payback period be?

PERFORMING ENERGY AUDITS

Experience has shown that children love energy audits. Audits have all the right components for a fun thing to do. Energy audits can be turned into field trips, in which case they become even more fun. And, unlike some field trips, the kids learn something they can use in real life.

Energy audits can be performed on many levels. Professional engineers develop computer models and use expensive monitoring equipment. Present school budgets preclude such behavior. Actually, the more glaring deficiencies can be easily discovered with a minimum of fanfare. And these are the ones that often prove to be the most cost effective in terms of retrofit.

Energy audits are mostly performed in Maine to lessen the demand for fuel for space heating. Our cold winters make it necessary to control the temperature of living spaces for at least six months of the year. Next to heating, lighting requires the largest chunk of energy. Examine these two areas separately.

When we heat a building in winter we are trying to keep warm interior air from going outside and cold exterior air from coming indoors. The way to keep warm air inside is by filling the cavities of the building with insulation. Insulation is a material that minimizes heat loss by retarding conduction. Conduction is the method of heat transfer when heat moves through a solid, like it does through the handle of a hot cast iron frying pan. Insulation blocks this transfer with dead air spaces. The class should be able to conclude which materials are conductors and insulators by thinking of them in regard to the air spaces they contain. Thus, we know wood is a better insulator than steel.

We can slow down the flow of heat from the building by using insulation. But at the same time, cold outside air is coming inside through small cracks and openings in the walls and and around doors and windows. How can we stop the air infiltration? We can use weatherstripping for this purpose. Weatherstripping is made of metal, plastic, foam or felt strips. Do you think metal is a better material than foam? Why? HINT: which is a better insulator?

We use artificial lighting to bring the level of illumination inside a building to the intensity suitable for the task at hand. We are generally familiar with two types of lights, incandescent and Flourescent. Incandescent light bulbs are much less efficient than flourescent light tubes. They are less expensive to buy, however, as are their fixtures. But a 40-watt incandescent bulb gives off only about 1/3 as much light as a flourescent tube of the same wattage. (A watt is a unit of electrical power.) Also, the incandescent bulb is converting as much as 90 percent of its electricity to heat. Feel the difference by carefully placing your hand near both lamps.

It should be noted that the most energy efficient form of lighting is natural outdoor light through windows, when available.

HOW TO CONDUCT AN ENERGY AUDIT

The first place to conduct an energy audit is in the school. Since students spend most of their day in school, they should become aware of how energy is used in the building. Energy audits must be conducted in the winter in order to notice

the differences between the heated building and the cold outside.
NOTE: In 1977, Maine voters passed a $10 million bond issue to retrofit state-owned buildings and public schools. It is likely that many of the most blatant areas of energy waste have already been eliminated from your school. Your principal should be able to help you obtain a copy of the building's energy audit recommendations and payback periods from the Department of Education in Augusta.

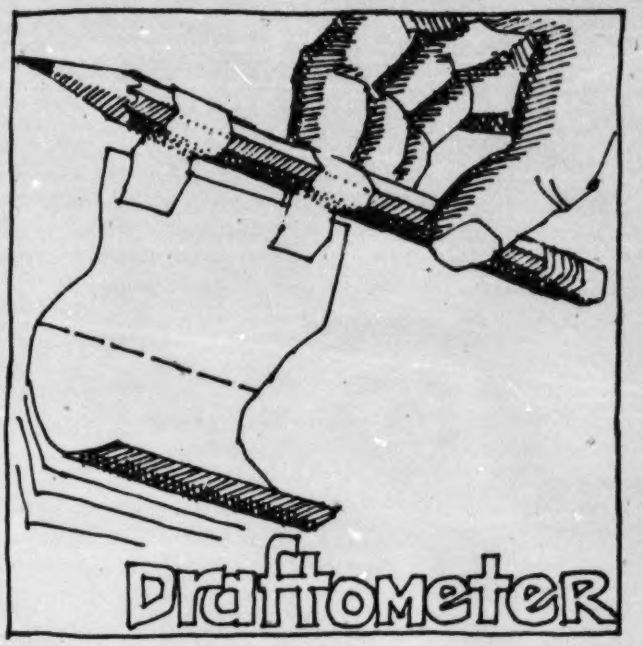
1. The best way to kick off the energy audit experience is with a visit from the school custodian. He should present a lecture on how energy is used in the school and how it is controlled. The students can then be given a tour of the boiler room or furnace area and be told how the fuel is converted to produce heat for their classrooms. If the school has a kitchen, they should become familiar with how water is heated and stoves are operated. They should be taken to see the school's electric meter and told what it measures. Later in this unit, they will learn how to read it themselves.

2. Now the class can proceed by themselves.
WHAT YOU'LL NEED: two thermometers. A roll of toilet paper, pencils and tape.
NOTE: every school will obviously be different. Older schools tend to be easier to audit because they are draftier. Newer schools may contain various levels of insulation and have less air infiltration. Some windows will be sunny; north facing windows always feel cold. To save time, teachers should tour the building prior to the audit and make note of areas where energy waste is apparent.

3. Have students feel the difference between the wall and window on a sunny day and a cloudy day. What is the wall made of? Which is colder, and why? Do the windows have two panes of glass or one? Storm windows? Curtains or shades?

4. Take the temperature in several locations. Take one reading in a sunny window, one in the classroom near the floor, in the classroom near the ceiling, in the hallway, in a closet and in the gym. Record the results. Do any of the readings seem too high or too low for the area and the way it is being used?

5. Construct a draftometer: A draftometer (pronounced draft-om-it-er) is a low technology instrument for detecting air infiltration. It is constructed by taping a couple of sheets of toilet paper onto a pen or pencil. Any draft will make the paper shutter, revealing areas where cold air is entering the building.



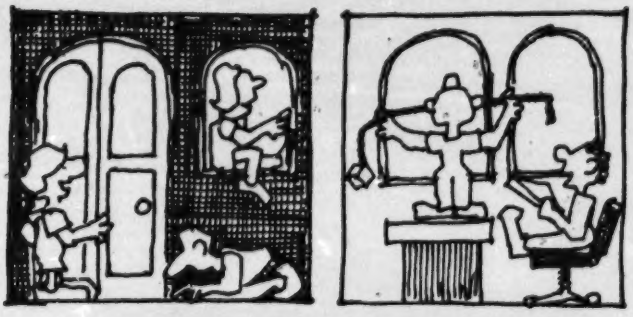
Use the draftometer to detect infiltration at exterior doors and windows. What effect do drapes and window shades have on blocking infiltration? What is their effect in insulating windows from heat loss? Do you make it a habit to draw shades and drapes on winter nights? How can this practice also help keep a room cooler in the summer when the sun is shining?

6. Airlocks: An exchange of fresh air through an occupied space is desirable. In fact, it's essential. We could live in giant Tupperware containers if we didn't need to breathe fresh air. But too much fresh air can be bad, especially in the winter when each newly introduced volume must be heated. Optimumly, we should want to bring in only as much fresh air as we need. A greater rate of exchange is needed in the kitchen, for example, than in a classroom.

We know air infiltration is taking place at small cracks around windows and doors. But a substantial amount of cold air enters a building each time a person enters through an open door. In high traffic buildings, such as schools, infiltration is especially prevalent.

To keep freezing air from meeting 68 degree air, a tempered air space should be present. This is called an airlock. Many schools, department stores and office buildings have airlocks. They consist of two exterior doors. The principle is simple. One door is open at a time, preventing cold air from directly entering the building.

But installing an airlock is not enough. It must be used properly. There is a tendency for people to hold both doors open, or to open the second door before the first has shut. Does your school have an airlock? Is it used correctly? Would students use it correctly if they understood how it works?



7. Lighting: How are lights used in your school? What type of lights are installed? Are lights left on in unoccupied areas? Could some lights be turned off in areas that receive sufficient natural light? Who controls the lights in the school, teachers or custodians? Could children be in charge of turning on and off lights?

HOME ENERGY AUDITS

After the class feels confident about identifing energy use situations in the school they should conduct a similar audit in their homes. This is a good weekend project. Family members can help. Have them use the audit sheet enclosed. Have the class discuss findings at the conclusion.

COMMUNITY FIELD TRIP AUDIT

The logical extension of student awareness after auditing their school and home is the examination of a public building. This allows the student to see the "real world" value of managing energy. They can also understand the relationship between money and energy in the form of taxes (which their parents pay) to heat and light public, municipal buildings.

The town hall, police station or library are prime candidates. Pick the oldest, draftiest building you can find and get permission to audit the premises. Visit

the building prior to the class audit and locate the major problems. This will save time. Compile an appropriate audit sheet and try to arrange for adult supervision if the class is large. Allow the young energy sleuths to uncover thermal inefficiencies in the building. If at all possible, arrange for an interview with the town manager, police chief, etc.

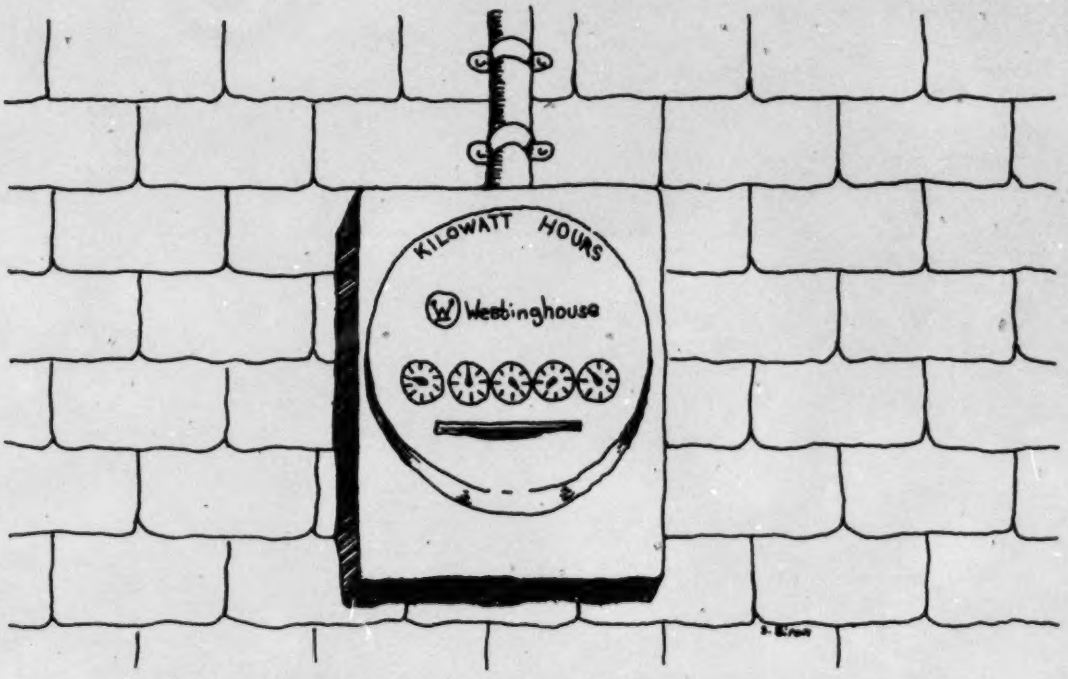
Have a list of questions prepared that cover information similar to that offered by the school custodian. How old is the building? What type of fuel does it use? Is it insulated and are there any plans to make it more energy efficient? If any new construction is planned, will it incorporate passive solar design principles? If not, why not?

HOW TO READ AN ELECTRIC METER

Homes, schools and town buildings all have one thing in common, they use electricity for lighting, and, possibly for heating. We're well aware that energy is not free, so there must be a way for power companies to keep track of how much electricity we are using so they'll know what to charge us. Keeping track of electrical consumption is the job of an electric meter.

Electricity is measured in kilowatt hours (KWH). One KWH is the amount of electrical energy needed to run a 100 watt light bulb for 10 hours.

One way to find out how much electricity is used in a building is to examine the monthly bill sent to us by the power company. Total KWH's are listed on the bill. But we can keep track of consumption ourselves by learning to read the meter. It's easy, a little like reading a clock. Find out where it's located and use the guide below for help.



Most electric meters have a set of dials that read in multiples of ten. The dial on the right reads tens of kilowatt hours (KWH); the next one reads hundreds of KWH's, and so on. Don't be confused by the direction of the numbers, some read clockwise, others counter-clockwise. When the pointer is between two numbers, always record the lower figure.

ANSWER: 79,420 kilowatt hours

HOME ENERGY AUDIT

NAME_____

(Ask family members for help if you need it)

1. How many windows are there in your house? _____

2. Do they have storm windows or two panes of glass? _____

3. Do the windows have curtains or shades?_____

4. Are the curtains or shades closed at night? _____

5. How many outside doors does your house have? _____

6. Is there an "airlock" between outside doors? _____

7. If no airlock, are storm doors installed? _____

8. Build a draftometer. Check for cold air leaking around all windows and outside doors. Would you consider them:

(circle one) A. very leaky B. fairly leaky

C. fairly tight D. very tight

9. What type of heating fuel or fuels does your house use?

A. oil B. wood C. electric D. gas E. other

10. If you use wood, do you burn it in a stove or fireplace?

THIS SPACE FOR NOTES OR COMMENTS:

HOME ENERGY AUDIT

10. Check your heating system's thermostat, if you have one. Do it in the morning and in the evening before bedtime. If your family changes the setting at certain times of the day, what are these settings?

A. Morning temperature_____

B. Evening temperature_____

11. If you have a thermometer at home, take the temperature at the following locations, once in the morning, once at night.

A. Windows that receive bright sunlight _____ _____

B. Windows that receive little sunlight _____ _____

C. Upstairs, near the ceiling _____ _____

D. Downstairs, near the floor _____ _____

12. Does your house have any insulation? Ask a family member for help, and, if possible, see if there are any places in the house where it can be seen, such as in the attic.

A. Where is insulation located? _____

B. What type? _____

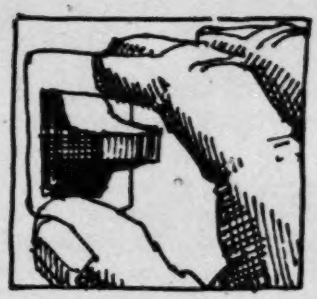
C. How thick? _____

13. Read your electric meter. Do it once in the morning. Wait two days, then read it again in the afternoon. Record the results. Was the dial moving faster in the morning or the evening?

morning

afternoon
(two days later)

chapter four: future scenarios



OBJECTIVES

1. To consider how energy might be used in the future.
2. To discuss energy projections.
3. To formulate our own projections.
4. To examine energy growth as exponential growth.
5. To consider the merits of certain technological levels.

GLOSSARY

1. PROJECTION: an educated guess about a future situation.
2. DESIRABLE TECHNOLOGICAL LIMIT: a satisfactory level of refinement where technology matches the task to be performed.
3. EXPONENTIAL GROWTH: growth by geometric proportions.

Conservation has been identified as the method that will give us time to develop the new fuel sources that will power our world in the future. But it's difficult to predict how much of which new energy source we'll need, and when we'll need it. There is a great of debate over how long our conventional fossil fuels will last. We know, however, that there is a great deal of time between discovery of new sources and their popular use. That is why energy planners are working now to develop fuel sources that we will need in the year 2000 and beyond.

FUTURE ENERGY SOURCES

The energy sources we'll be using in the future fall into three categories:

A. Technology that is presently available and/or awaiting refinement. An example is conversion of the sun's rays for space and water heating. This is a technology that is currently available. It is likely to become further refined as use increases.

B. Technology that is possible. An example is an atomic reactor that converts non-fissionable uranium into fissionable plutonium. This is an experimental technology that has not been refined for commercial use.

C. Technology that is not presently possible. An example is the effort by many scientists to control the process that powers the sun itself, nuclear fusion. It is hoped that some day fusion reactors can be built that will be powered using a form of hydrogen found in water.

PROJECTIONS

What amount of which fuel should the US be using in the year 2000? That's hard to say. Energy planners must make educated guesses called Projections. They must take into account what sources of energy we now use, how fast we will deplete them, how much we will need in the future and how long it will take to develop these new fuels. Making projections is not easy, and they are not always accurate. In 1952, the Paley Commission reported to President Harry Truman:

"Efforts made to date to harness solar energy economically are infintesimal. It is time for aggressive research in the field of solar energy---an effort in which the United States could make an immense contribution to the welfare of the free world...by 1975, solar energy could account for 10 percent of the nation's total energy consumption."

How much faith should we put in energy demand projections? How can we tell the good ones from the bad ones? What can we guess about the projections by noting the source? For example, would a company that builds nuclear reactors predict that solar energy will become the dominate energy source in the future? Is it possible that the person making the projection represents a group that has a special interest in seeing his projection come true?

Atlantic Oil

By MARK POTTS

NEW YORK (AP) — Several years after the oil presumed to be off the Atlantic Coast was ballyhooed as the answer to East Coast energy needs, you still can't fuel your car or heat your home with it.

Legal and technical problems, and just plain bad luck, are keeping the area from playing a key part in the nation's energy picture.

Now, though, the stage is set for another try.

On Wednesday, the federal government will open bids from oil companies for drilling rights in more areas of the Baltimore Canyon, the best-known of the Atlantic offshore areas. And a U.S. Court of Appeals last week lifted an injunction against the sale of sites in the Georges Bank area off Cape Cod.

The East Coast offshore oil fields were never intended to help relieve the nation's reliance on oil imports before the next decade. But now even the most optimistic analysts don't expect to see energy from the Atlantic before 1980.

In fact, the amount of natural gas produced from the two successful Atlantic offshore wells in a day would be less than enough to heat 100 average-sized homes for a year.

"I think it's going to be a long, slow process to find the oil and gas out there," one industry source said.

The numbers involved are what caused the initial optimism. The Atlantic Coast area is believed to hold 13.5 trillion cubic feet of natural gas — about eight months worth of U.S. supply — and a lesser amount of crude oil.

Five years ago, with foreign oil prices

EXPONENTIAL GROWTH

One reason why it is hard to accurately project energy needs is because it is hard to identify the dynamics of energy growth. The key to understanding the seriousness of uncontrolled energy growth requires an understanding of Exponential Growth. These two examples will help.

EXAMPLE ONE: Give the class the following choice. They can either have $1,000 a day for one month (thirty days), or they can have $2 the first day, doubling the figure every day until the end of the month. Split the class up in accordance with who thinks they'll have the most money at the end of the month.

If you choose $1,000 the first day and received the same amount every day, you would have $30,000 at the end of the month.

If you chose $2 on day one, you would have $4 on day two, $8 on day three, $16 on day four and $32 on day five. That doesn't sound like a good deal---so far. But let's jump to day 10, day 15 and finally day 30. On the tenth day you would have $1,024. On the fifteenth day you would finally pass the monthly total for the other group by chalking up $32,768. On the thirtieth day you would end up with a grand total of $673,741,824. Work it out in class with the students and see what they come up with!

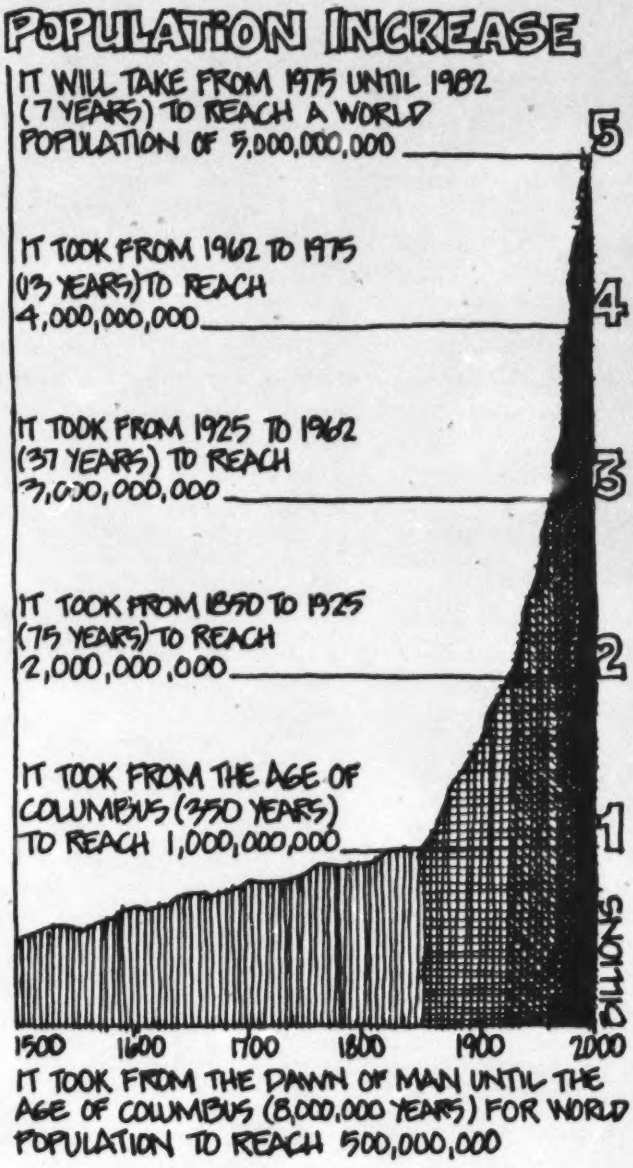
EXAMPLE TWO: An even more graphic way to view energy growth is with the study of population growth. As the graph and chart show, the doubling times grow shorter. If we think of energy growth in this light, we can see that the next time our energy growth doubles, the world will be using more energy that it has ever used throughout all of history!

MAKING OUR OWN PROJECTIONS

As a prelude to guessing how energy might be used in the future, children should look back to see how energy was used in the past, in their grandparent's time. Interviews should be arranged with the oldest family members possible to find out how they did the following things when they were growing up.

A. How did they heat their homes?
B. How did they cook their food?
C. How was food kept cool?
D. What sort of transportation was used?
E. What was the popular form of entertainment?

This information could be compiled on take-home sheets similar to the home audit questionnarie. They can later be compared and discussed in class.


POPULATION INCREASE
IT WILL TAKE FROM 1975 UNTIL 1982 (7 YEARS) TO REACH A WORLD POPULATION OF 5,000,000,000
IT TOOK FROM 1962 TO 1975 (13 YEARS) TO REACH 4,000,000,000
IT TOOK FROM 1925 TO 1962 (37 YEARS) TO REACH 3,000,000,000
IT TOOK FROM 1850 TO 1925 (75 YEARS) TO REACH 2,000,000,000
IT TOOK FROM THE AGE OF COLUMBUS (350 YEARS) TO REACH 1,000,000,000
IT TOOK FROM THE DAWN OF MAN UNTIL THE AGE OF COLUMBUS (8,000,000 YEARS) FOR WORLD POPULATION TO REACH 500,000,000
5
4
3
2
1
BILLIONS
1500
1600
1700
1800
1900
2000

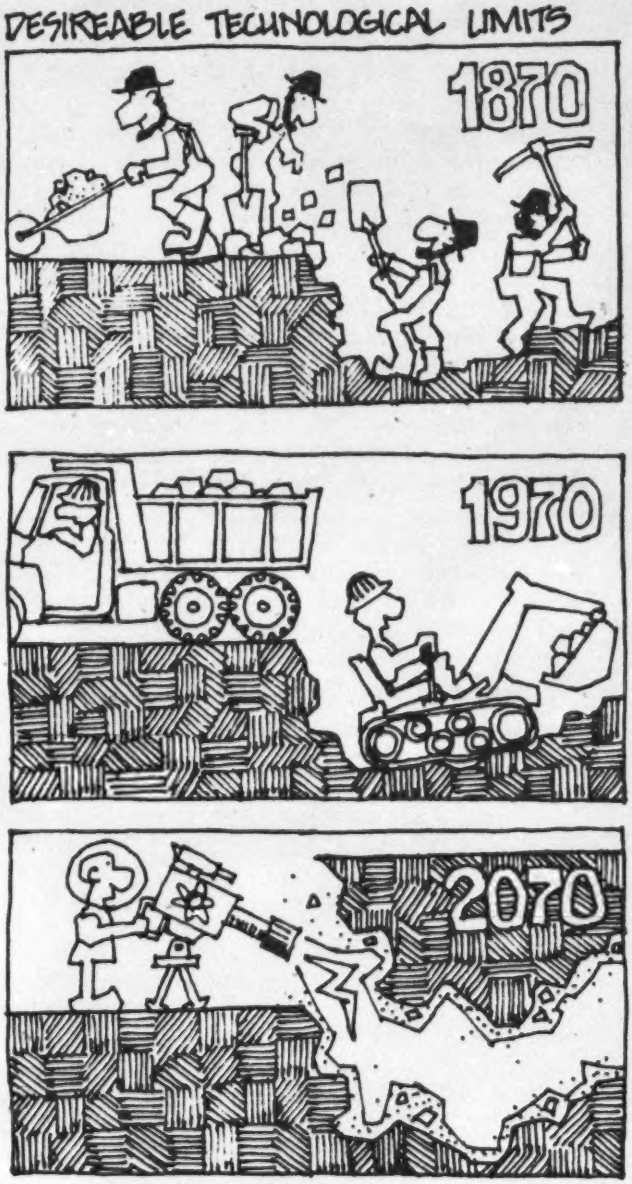
The next assignment makes an excellent test question. It involves looking ahead. What will life be like in Maine in 25 years? What sort of transportation will we have? How will we heat our homes? Students should be cautioned against developing "Star Wars" scenarios in which space ships traverse the solar system. They should be required to justify their ideas in terms of how the energy needed to fulfill their projections will be produced and used.

Make a comparison of the technology involved in heating a house two ways: by electricity produced at a nuclear power plant and with heat produced by direct sunlight, such as in a passive solar house. Do they both accomplish the same goal? Which requires a higher level of technology? Which is more convenient to use? If you had a choice, how would you heat your house, and why?

MORE ENERGY PHILOSOPHY

The student's projections should be discussed in class. Certain conclusions can be drawn about the way these youngsters perceive the future. To further stimulate thought on the matter, pose the following questions. Are we headed towards a more technological society, or perhaps moving back in the other direction? Can certain technological levels exist together? For example, a person in Maine can heat his home with wood, although the electricity he uses may come from a nuclear power plant. Have we reached the limits of growth in some areas, that is, have we pushed our suburban areas as far as we can, do we have enough cars, televisions and toasters? Is continued growth a good thing? Why or why not? Is population growth entirely related to energy growth? If the population slows down, will energy growth follow suit, or can less people use more energy?

A thought on Desirable Technological Limits: In the 19th century, if a man wanted to dig a foundation for a house, he used a pick and shovel. In the 20th century bulldozers and backhoes were invented. They ran on oil and did the work much faster and easier. What further refinements could be made in the 21st century? Will bulldozers be atomic powered? Will they be able to dig a foundation in even less time and with less effort? Has the equipment finally matched the task at hand and reached its Desirable Technological Limit? Should we go back to digging with a pick and shovel?



resources

THE BEST PRESENT OF ALL
National Wildlife Federation, 1412 Sixteenth St NW, Washington, DC 20036. (24 pages. free single copy, bulk copies 15¢ each.)

ENERGY HISTORY OF THE UNITED STATES, 1776-1976.
US Department of Energy, Office of Public Affairs, Washington, DC 20585 (Wall chart and manual, nominal fee).

MICKEY MOUSE AND GOOFY EXPLORE ENERGY
Exxon, Public Affairs Dept., Room 4045 H, Box 2180, Houston, Texas 77001. (36-page comic).

SCIENCE ACTIVITIES IN ENERGY
US Department of Energy, Technical Information Center, Box 62, Oak Ridge, Tenn. 37830. (four file folders with activities sheets covering solar energy, conservation, chemical energy and electrical energy.)

TILLY'S CATCH-A-SUNBEAM COLORING BOOK
Solar Service Corp., 306 Cranford Road, Cherry Hill, NJ 08003 ($1.50 each)

FACTS ABOUT OIL
American Petroleum Institute, 2101 L Street NW, Washington, DC 20037 (44-page booklet, 35¢ each)

NEW FUELS FROM COAL FACTSHEET #15
National Science Teachers Asso. 1742 Connecticut Ave.NW, Washington, DC 20009. (four page booklet, free, send stamped, self-addressed envelope).

NUCLEAR POWER QUICK REFERENCE
General Electric, Nuclear Energy Division, San Jose, Calif. (48 pages)

ENERGY CONSERVATION: EXPERIMENTS YOU CAN DO
Edison Foundation, Cambridge Office Plaza, Suite 143, 18280 West Ten Mile Road, Southfield, Mich. 48075 (32-page booklet)

THE HOUSEHOLD ENERGY GAME
University of Wisconsin Sea Grant College Program, Communications Office, 1800 University Ave, Madison, Wisconsin. (20 pages, free single copies, bulk orders 15¢ each).

ENERGY: LESSON GUIDES AND ACTIVITIES FOR INTERMEDIATE GRADES.
New York State Electric and Gas Corp. Market Services Department, Binghamton, NY 13902. (lesson guides for students and teachers, nominal charge).

LIVING WITHIN OUR MEANS: ENERGY AND SCARCITY, ENVIRONMENTAL EDUCATION INSTRUCTIONAL ACTIVITIES
State Education Dept., Albany, NY 12234 (Two books, 86 and 106 pages)

THE ENERGY CHALLENGE
The Energy Challenge, Box 14306, Dayton, Ohio 45414. (a booklet of spirit masters and teacher's guide)

TIPS FOR ENERGY SAVERS
Tips for Energy Savers, Energy Conservation Now, Pueblo, Colo. 81009. (46-page booklet)

SOLAR ENERGY
US Department of Energy, Office of Public Affairs, Washington, DC 20585 (49-page booklet)

SOLAR DWELLING DESIGN CONCEPTS
US Department of Housing and Urban Development, Supt. of Documents, US Government Printing Office, Washington, DC 20402 (146-pages, $2.30)

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Maine Audubon offers a number of energy-related publications. For a current list, write: Maine Audubon Energy Department, 118 Route One, Falmouth, Maine, 04105.